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ECL 284

SHOVED FOR SURE!

A freight train and an automobile collide at a grade crossing, killing the two occupants of the car. Could this accident have been avoided?

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At about 8 o'clock on a clear dry evening in mid November, a freight train was traveling in southern Michigan on a straight and level track. The two power units and 65 cars (total weight of 4,631,600 pounds) were running at 38-40 mph approaching a grade crossing, heading south. An eastbound automobile with two occupants was approaching the same grade crossing. (Exhibit 1)

Visibility was excellent, the headlight was operating on the leading power unit, the engineer had sounded the whistle at 1500 and 600 feet before the crossing and the bell on the train was ringing. The engineer (on the right side of the power unit cab) saw a reflection of lights on the tracks when he was about 200 feet from the crossing. His view was partially blocked by railroad cars sitting on a parallel passing or storage track to his right. The engineer noted a change in the reflection of the automobile headlights as if the car had either hit a bump, or had started to brake and then speeded up, or had started to speed up and then braked. He saw the automobile itself when he was about 150 feet from the crossing. At that time he took no action of any kind toward applying brakes. In fact, the police report quotes him as saying: "I observed the vehicle approaching the intersection, slowing. I called to my fireman, 'if he goes we're going to get him.' He went, we hit. I put the train in emergency."

The train and automobile did indeed hit. There was damage to the left front corner of the leading power unit and the left side of the second power unit. There was also damage to the station which was on the south-east corner of the grade crossing. Both occupants of the car were killed. The body of the female was 92 feet south, the car was 154 feet south, and the body of the male was 293 feet south of the center of the crossing street, all on the east side of the tracks.

The engineer did apply full emergency braking immediately prior to impact or on impact. He reported that the power units and 30 railroad cars had crossed the street when the train came to a full stop. (The average railroad car length is about 50 feet.)

The fireman was riding on the left side of the cab and was unable to see anything on the right side of the power unit. He first saw the automobile when it appeared on the left side of the power unit at (or following collision). He saw the automobile hit the depot and bounce back into the left side of the second power unit.

It was the fireman's stated opinion that this crossing was the most dangerous spot on the whole subdivision. (There was only a grade crossing sign, no automatic signal.) He further believed that a driver approaching from the west would not see the engine, had he not been alerted by a whistle (what about the power unit headlight?). He also believed the engineer would not see an automobile until it was very close. The fireman confirmed that 30 railroad cars had crossed the street when the train came to a full stop.

Consider this situation. Can you estimate the speed of the automobile? Was the accident inevitable, given the apparent positions of the train and automobile a few seconds before impact? Was it possible that the accident and fatalities could have been avoided? Summarize your case and make calculations as appropriate to support your viewpoint.

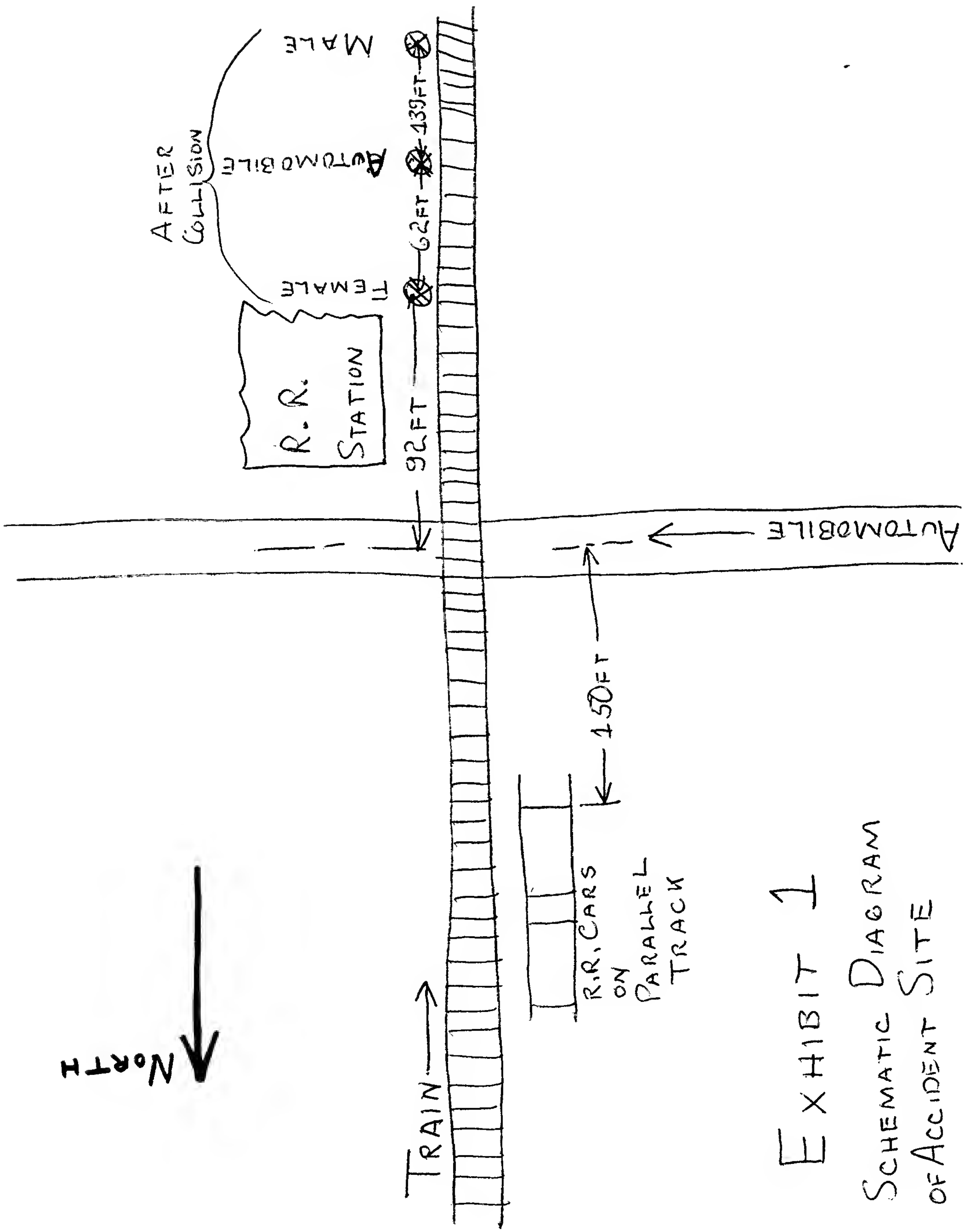

EXHIBIT 1

SCHEMATIC DIAGRAM OF ACCIDENT SITE

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Part B

The fact that the automobile finally came to rest on the opposite side of the railroad tracks from its initial position, and the location of the damage on the leading power unit, indicate that the "point" of collision between the leading power unit and the automobile was on the driver's side of the automobile and to the left of the center of the power unit. In addition, the fact that the automobile hit the depot and rebounded against the second power unit, further implies the automobile had a "high" speed and must have been nearly across the tracks.

What was the speed of the automobile? No one knows for sure since the occupants of the automobile were killed and the train engineer and fireman made no estimate. We can estimate the speed since we know that the second power unit was damaged from being hit by the automobile rebounding from the depot. This is an obvious situation calling for impulse and momentum calculations.

The applicable equation is

$$e = - \frac{V_2' - V_1'}{V_2 - V_1}$$

where e is the coefficient of restitution, 2 indicates the automobile, 1 indicates the depot, primes indicate velocities after impact, and the absence of primes indicates velocities before impact. Since the depot is an "immovable" object, this equation reduces to

$$e = - \frac{V_2'}{V_2}$$

If the impact between the automobile and depot were perfectly elastic, the automobile would have rebounded with "no damage", i.e., the coefficient of restitution would be one. If the impact were perfectly inelastic, the automobile would not rebound at all, i.e., the coefficient of restitution would be zero. Obviously, neither case is satisfied. Then what does one use as a coefficient of restitution? Questions directed to some knowledgeable people gave estimates of 0.2 to 0.5. In the book, "IMPACT" by W. Goldsmith, St. Martin's Press, 1960, there is a figure which indicates a range of about 0.2 to 0.4. Considering the damage to the train, and using a coefficient of restitution of 0.5, it was estimated that the automobile was traveling at something in the order of 50 mph.

Considering the train, we know that basic kinematic relationships apply. Thus, we know that

$$V_f^2 = V_i^2 + 2\ as$$

where V_f is the final velocity, V_i is the initial velocity,

a is the acceleration, and s is the distance traveled. Since the train was traveling at 38-40 mph and came to a full stop in about 1500 feet, the acceleration was about 1 foot/second/second (negative, i.e., a deceleration).

The speed of the train at 38 mph is 55.6 ft/sec. The time required to travel 200 ft at that speed is 3.6 seconds. The time required to travel 150 ft at that speed is 2.7 seconds. If the emergency stop were applied on the train at

then:	200 ft	150 ft
new speed at crossing, fps	52.0	52.9
new time to crossing, sec	3.7	2.8
time differential, sec	0.1	0.1
distance traveled in prior time to crossing, ft	193.5	146.4
distance from crossing using prior time to crossing, ft	6.5	3.6

Considering the automobile again, we calculate that a body traveling at some velocity will cover a distance as indicated:

Velocity mph	Velocity fps	Distance ft (in 0.1 sec)
40	58.8	5.9
45	66.0	6.6
50	73.2	7.3
55	80.5	8.0
60	88.0	8.8

Could this accident have been avoided? It appears that the driver of the automobile believed he (or she) could beat the train to the crossing, and possibly speeded up to do so. If the driver had decided to try to stop or turn off the street parallel to the train, it is possible that the accident would have been avoided. Alternatively, the injuries might well have been less severe.

There is no question that the train engineer made no attempt to slow down as he believed there was no chance of missing the automobile if it attempted to cross under the circumstances. Had he applied full emergency stopping measures at the moment he saw the automobile headlights or even when he saw the automobile itself, there would have been a small but

perceptible increase in the time required for the train to reach the crossing. The automobile would also have traveled further forward in that same time interval.

Could the accident have been avoided? It appears that a different response from the driver of the automobile and/or the application of emergency stopping measures by the train engineer would probably have changed the situation from the actual event to a "close call."

It might be worth noting that after the accident, permanent barriers were erected across the street on both sides of the railroad tracks.